KINEMATICS AT THE INTERSECTION OF THE GARLOCK AND DEATH VALLEY FAULT ZONES, CALIFORNIA: INTEGRATION OF TM DATA AND FIELD STUDIES

LANDSAT TM INVESTIGATION PROPOSAL TM-019

PROGRESS REPORT: JANUARY 15, 1987 TO AUGUST 15, 1987

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Summary of Activities

The past seven months activities have concentrated on further processing and interpretation of TM data, extensive field work, and processing of SPOT data. Results of these analyses have led us to test and reject several of the geologic/tectonic hypotheses concerning the continuation of the Garlock Fault Zone (GFZ). We have determined that the Death Valley Fault Zone (DVFZ) is the major through-going feature, extending at least 60 km SW of the Avawatz Mtns. Two 5 km wide fault zones have been identified and characterized in the Soda and Bristol Mtns., forming a continuous zone of NW trending faulting. Geophysical measurements indicate a buried connection between the Avawatz Mtns. and the Soda Mtns. Fault Zone. Details of these activities are presented in later sections. Future work will involve continued field work and mapping at key locations, further analyses of TM data, and conclusion of the project.

Garlock Continuation/Death Valley Offset

The first hypothesis we examined is that the Garlock Fault Zone continues east of the intersection of the two faults at the Avawatz Mtns. into Kingston Wash (Figure 1). This idea was proposed by several people, notably Plescia, who did gravimetric studies in the area. His results suggested that a continuation of the GFZ separated extended terrain in the north from non-extended terrain in the south. Our work directly refutes this contention, and shows that there is no eastward continuation of the GFZ through Kingston Wash. The evidence is the following: 1) analyses of TM images show no east-west trending features in the area; the presence of a buried Garlock woud certainly have affected nearby bedrock, and possibly have disrupted surficial deposits; 2) the position of a possible eastward continuation is constrained to lie north of the Silurian Hills, and south of the Salt Spring Range. This is a corridor only 1/2 km wide, inconsistent with the 6 1/2 km width of the GFZ west of the intersection. 3) Field mapping in the Silurian Hills and TM image interpretation reveal only N-S trending structures, including a Tertiary graben, jointing and metamorphic foliation in bedrock, and faults. There is no evidence of any type of E-W structures, which would be expected along a major strike-slip fault.

Rejection of the hypothesis that the GFZ extends eastward precludes a corollary model that the GFZ offsets the DVFZ.

Garlock Offset By Death Valley Fault

If the GFZ does not continue eastward, perhaps it is/was offset along the DVFZ. To test this hypothesis, we examined processed TM images for lithologic and structural evidence of major left-lateral fault zones south of the intersection of the two faults. Comparison with the state geologic maps indicated that the only potential location for an offset GFZ was in Ivanpah Valley, 60 km to the south. A few faults shown on the state map possibly supported the presence of a buried fault zone. Analyses of the TM images failed to indicate any evidence for such a

feature. In addition, the projection of a possible zone to the southwest runs into the Old Dad Mountain, where bedrock contacts and NW-SE faults are uninterrupted (Figure 2). We therefore reject the hypothesis that the GFZ has been offset by the DVFZ.

Garlock Terminates In Avawatz Mtns.

The zone of deformation on the north side of the Avawatz Mtns. becomes a narrow line of faults, dominated by the Mule Springs fault. Analyses of TM and Thermal multispectral images reveals that this fault cuts very young fans; furthermore these fans are dioritic in composition, whose source is the Avawatz Mtns. Older fans affected by faulting to the north and west have no dioritic clasts. This indicates that the uplift of the Avawatz Mtns. is no older than Plio-pleistocene, and faulting along the NE side of the mountains is dominantly reverse-normal along west vergent structures. This is further supported by the presence of an imbricate stack of carbonate slices on the hanging wall block along the southern end of the Mule Springs Fault. No clasts of carbonate are found in older fans in the vicinity, only in very young fans. Slickensides measured in the field along this fault reveal only vertical movement, no strike-slip component being present. Therefore we conclude that a left-lateral strike slip Garlock Fault does not exist east of the intersection, and the pattern of faulting along the NE Avawatz Mtns. is vertical/thrust.

Death Valley Fault Zone Is Through-going

Soda Mtns.:

The previous sections lead us to conclude that the DVFZ is the major through-going structure, and field work and image interpretation support this conclusion. Extensive analyses and field mapping in the Soda Mtns. just SSE of the Avawatz has revealed the presence of a major fault zone, trending NNW-SSE. Combined use of SPOT data (Figure 3) and TM images (Figure 4) revealed the presence of numerous faults in a 5 km wide zone. These structures seem to offset bedrock, late Tertiary fan deposits, and younger fan deposits (Figure 5). Preliminary field work in the area corroborates these findings; we are starting detailed mapping to more precisely determine the age relationships of faulting to fan chronology, and to determine the sense and style of faulting. We can conclude that the faulting involves basement rocks; tectonism is near vertical and the faults are probably high-angle, strike-slip faults based on their straightness and attitude; they cut latest Pliocene and younger fan deposits, indicating recent activity; profound brecciation of the crystalline basement, more severe than that of younger sediments, indicates a long history of deformation; the overall style of faulting is similar to that seen in the Noble Hills along the DVFZ just NW of the intersection.

At the north end of the Sodas, a small patch of old fan

material seen on the images was examined in the field. Stream cuts through the hills allowed us to construct an interpretive cross-section (Figure 6b); steeply dipping playa and lacustrine sediments are uncomformably overlain by a thick carbonate horizon and coarse fan deposits. These in turn dip 20 degrees to the SW; a fault is inferred along the western border of the hills. The carbonate horizon may be correlative with Wells' 250,000 year old horizon in Silver Lake immediately to the NE. In any event, this outcrop indicates a tectonic history of multiple deformations: deposition of playa and lacustrine deposits in a basin; severe tilting of these deposits, and erosion of the surface; deposition or creation of a thick carbonate horizon and coarse alluvial gravel deposits above the unconformity, possibly 250 ka; tilting of the package and then development of a fan surface; uplift along a NNW-trending (?) fault. Further work and dating of the materials will clarify the age relationships; it is certain however, that a complex history is revealed by these findings.

We did seismic and gravity measurements along two generally E-W lines in the valley between the Avawatz and Soda Mtns. (lines shown on Figure 5) to determine if there were any buried structures which might represent the link between the DVFZ and the Soda Fault zone. Interpretation of the gravity data (Figure 6a) shows that the basin developed in the basement has its axis much further to the west than surface topography. Of greater importance is the suggestion of two offsets in the basement at the western end of the line. The surface projection of these features is directly on line with the NW extension of the major faults in the Soda Mtns. and also lines up with young faults found at the western edge of the southern tip of the Avawatz. This is strong evidence for a continuous structure between these two massifs. Further processing of the seismic data and analyses are on-going.

Bristol Mtns.:

Continuing southeast of the Soda Mtns. is Soda Lake and then the northern Bristol Mtns. We have analyzed TM images for this area and examined the area in the field in reconaissance. Interpretation of the TM images (Figure 7) shows a line of springs in Soda Lake aligned with the Soda fault zone. In the Bristol Mtns., a second major fault zone was identified, with similar tectonic style to the Soda zone: basement involvement, a 5 km width, multiple faults, linear faults, offset of fan deposits of all ages, tilting of fan deposits, etc. These preliminary results strongly suggest a further continuation of a single, major fault zone from the Avawatz Mtns. to at least the Bristol Mtns., a distance of 60 km. We will undertake detailed field examination and mapping of this fault zone in the fall to verify the image interpretations, determine age relationships, and evaluate style of faulting.

Future Work

We have requested a no-cost extension of this project until September 15, 1987 in order to complete our work. In the next

year we will complete the TM image analyses, and the detailed field mapping projects. Two Masters level theses are ongoing as part of this work; they will be completed next year: one involves the mapping activities in the Soda Mtns.; the other is examining the tectonic history of faulting along the northern edge of the Avawatz Mtns. through mapping of fans, determination of age and provenance. In the winter we will work in the Bristol Mtns., to map the faults and determine history of tectonism along this part of the DVFZ. We have requested additional Thermal multispectral aircraft data for the Sodas and Bristol Mtns. to supplement TM data for mapping fan composition and weathering characteristics.

Figure Captions

Figure 1. Sketch map of the Garlock and Death Valley Fault Zones, showing the possible eastward extension of the Garlock.

Figure 2. TM interpretation of area where offset Garlock Fault might be found in Ivanpah Valley. No evidence can be seen for a major fault zone, and extension to SW runs into uninterrupted structures in Old Dad Mountain.

Figure 3. SPOT panchromatic image of the Soda Mtns.

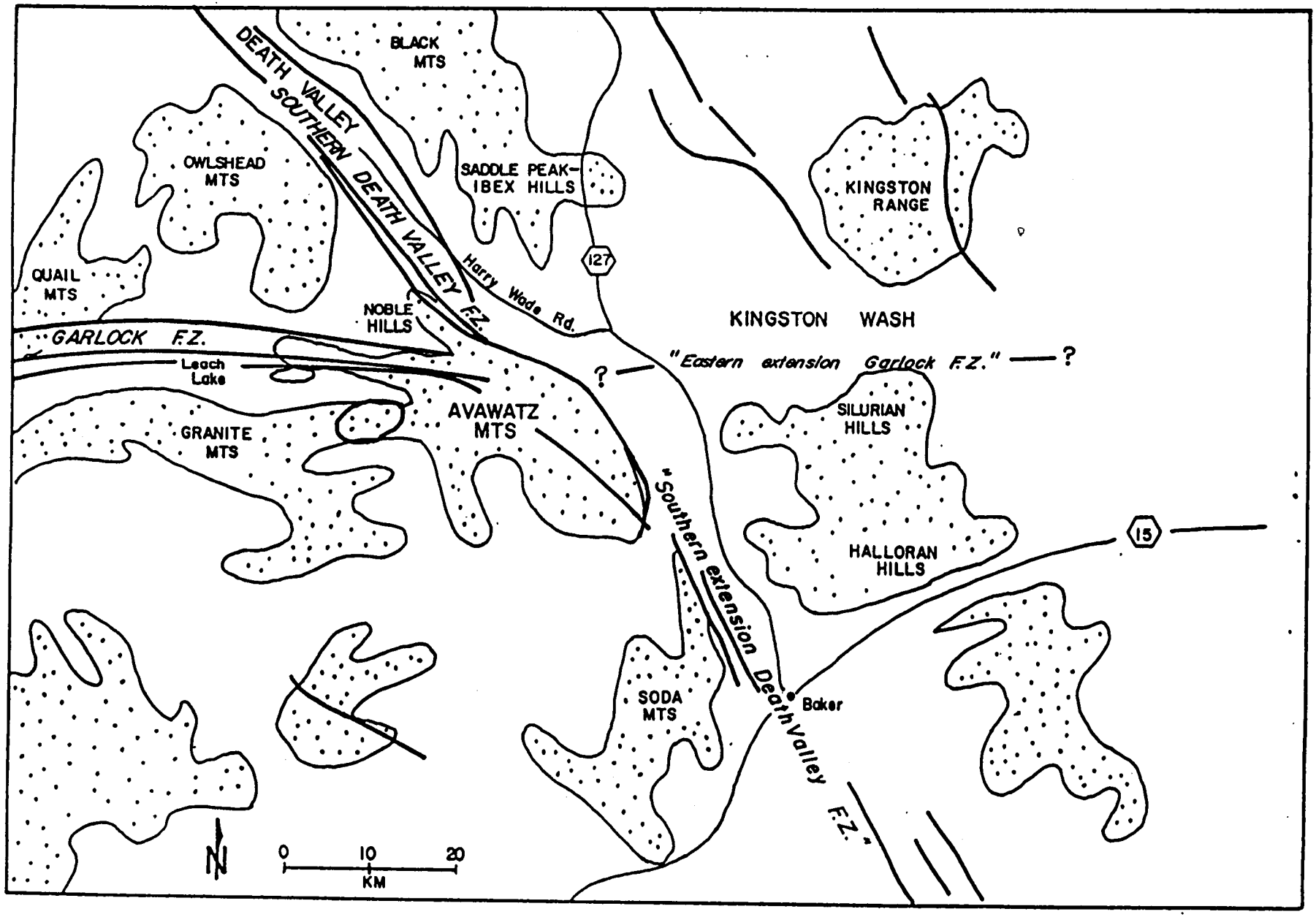
Figure 4. Processed TM image of Soda Mtns.(original in color).

Figure 5. Interpretation of TM and SPOT images for Soda Mtns. indicating presence of major fault zone.

Figure 6. a) Interpretation of gravity data along line 1 shown in Figure 5; b) interpretive section of outcrop of uplifted fan deposits north of Soda Mtns.; location shown on Figure 5.

Figure 7. Interpretation of TM data for Bristol Mtns. showing NW-trending fault zone interpreted to be continuation of DVFZ.

FIG 1


DEATH VALLEY SOUTHERN DEATH VALLEY F.Z.
BLACK MTS
OWLSHEAD MTS
SADDLE PEAK-IBEX HILLS
KINGSTON RANGE
QUAIL MTS
Harry Wade Rd.
127
NOBLE HILLS
GARLOCK F.Z.
Leach Lake
KINGSTON WASH
"Eastern extension Garlock F.Z." — ?
?
AVAWATZ MTS
GRANITE MTS
SILURIAN HILLS
"Southern extension Death Valley F.Z."
15
HALLORAN HILLS
SODA MTS
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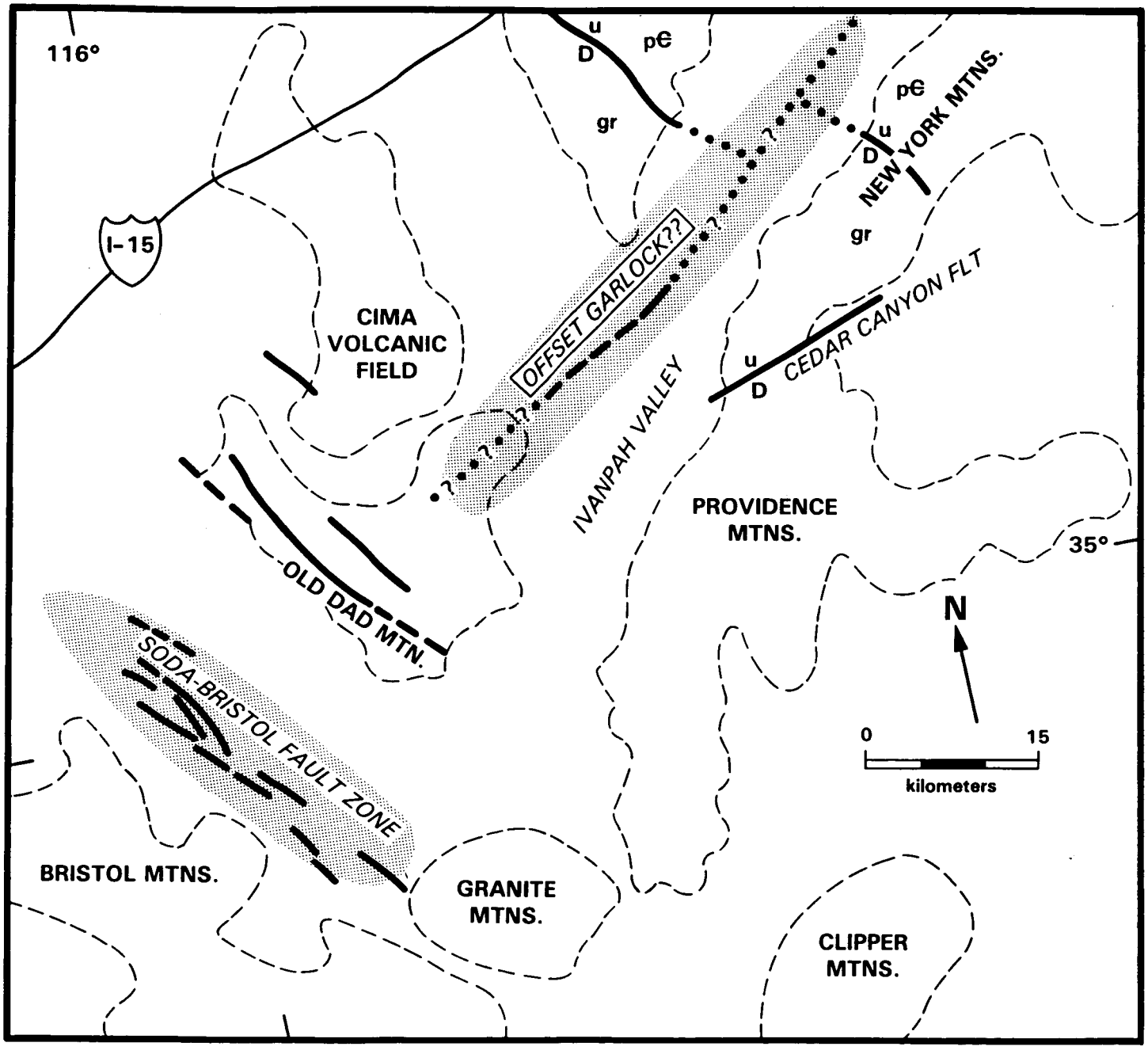
OFFSET GARLOCK FAULT: NOT IN IVANPAH VALLEY



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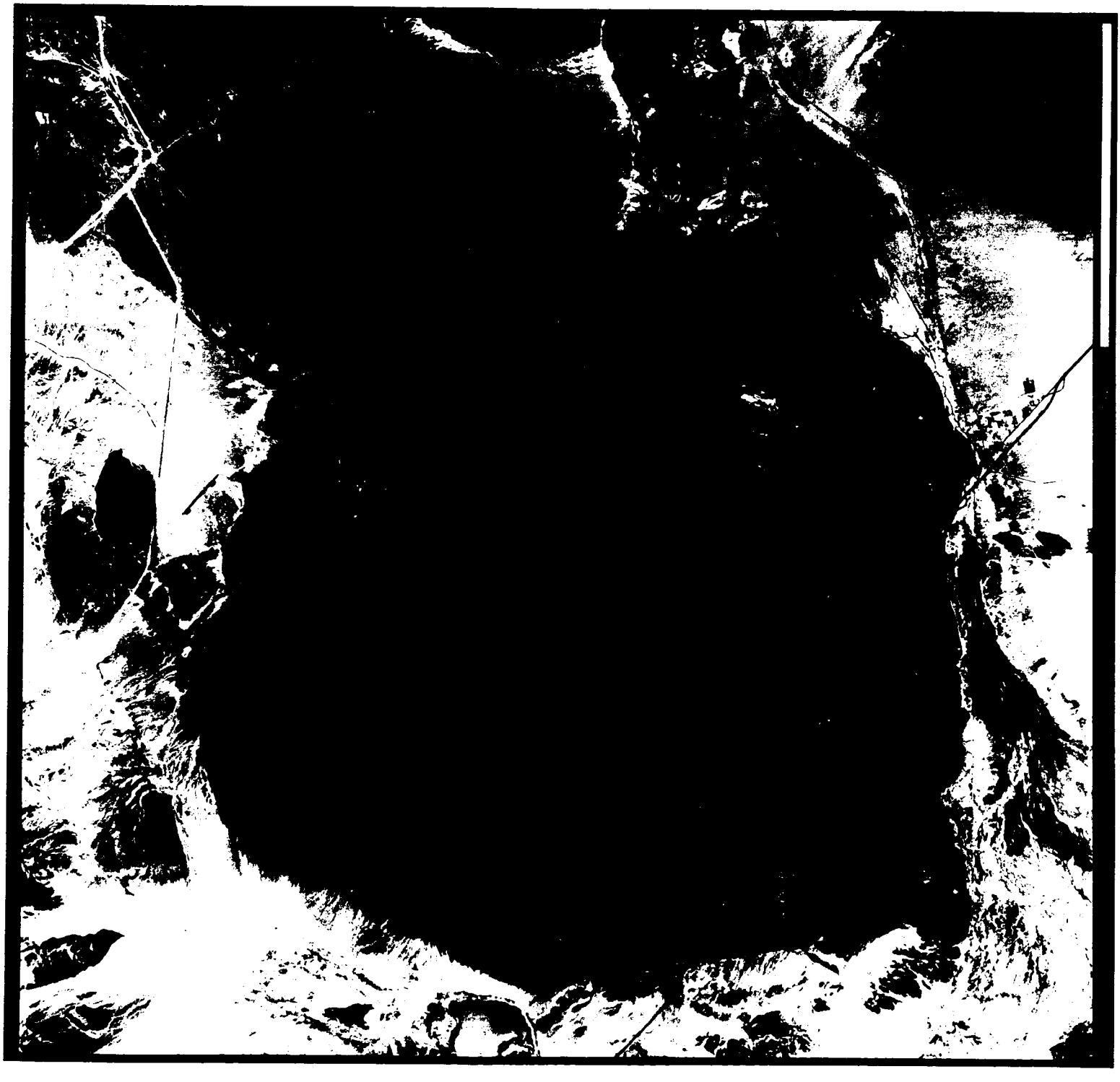

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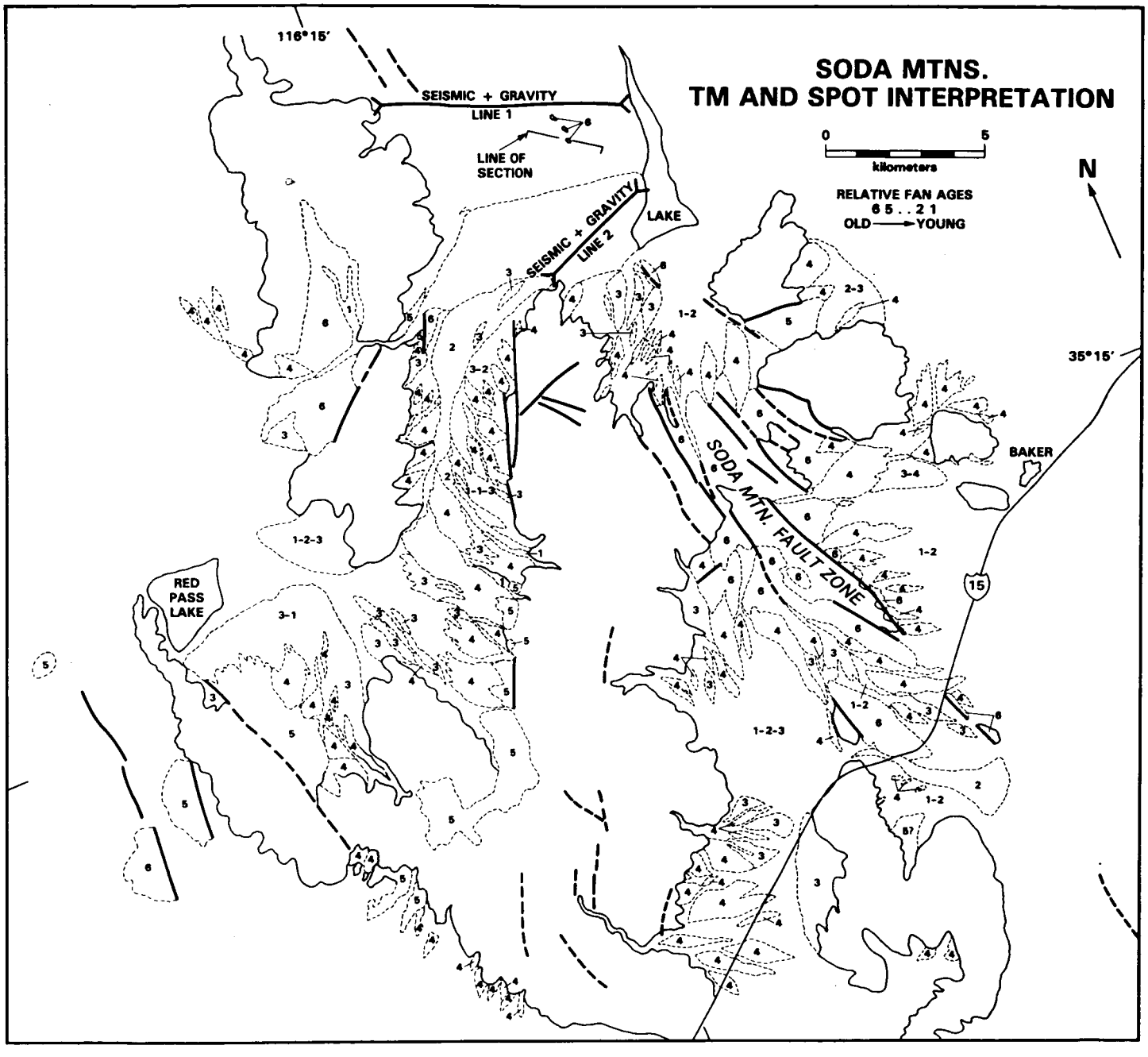
FIG 5


SODA MTNS.
TM AND SPOT INTERPRETATION
116°15'
35°15'
SEISMIC + GRAVITY
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LINE OF
SECTION
SEISMIC + GRAVITY
LINE 2
LAKE
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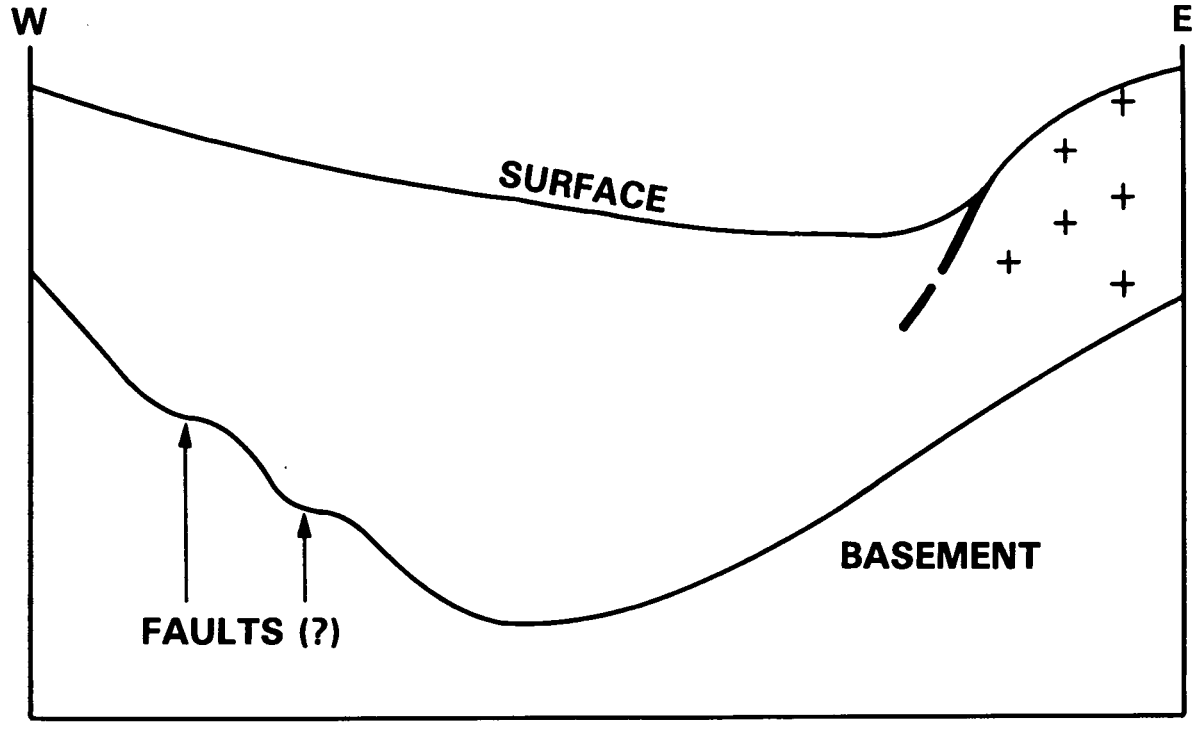
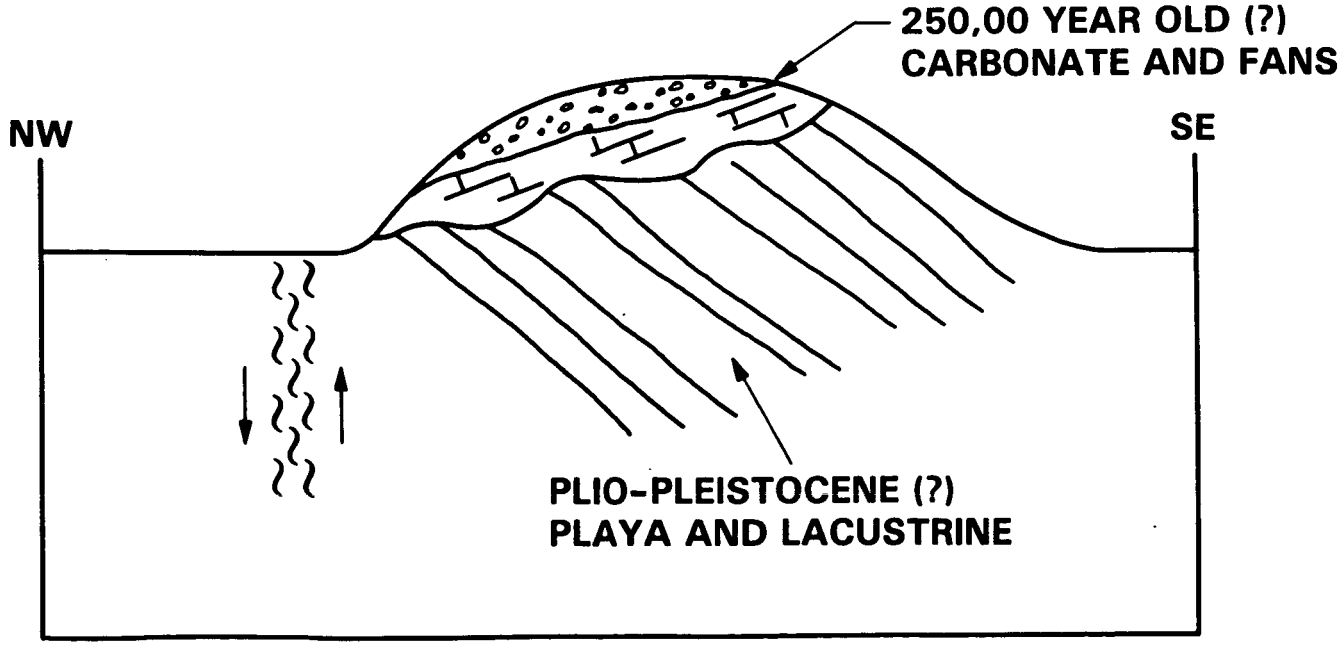
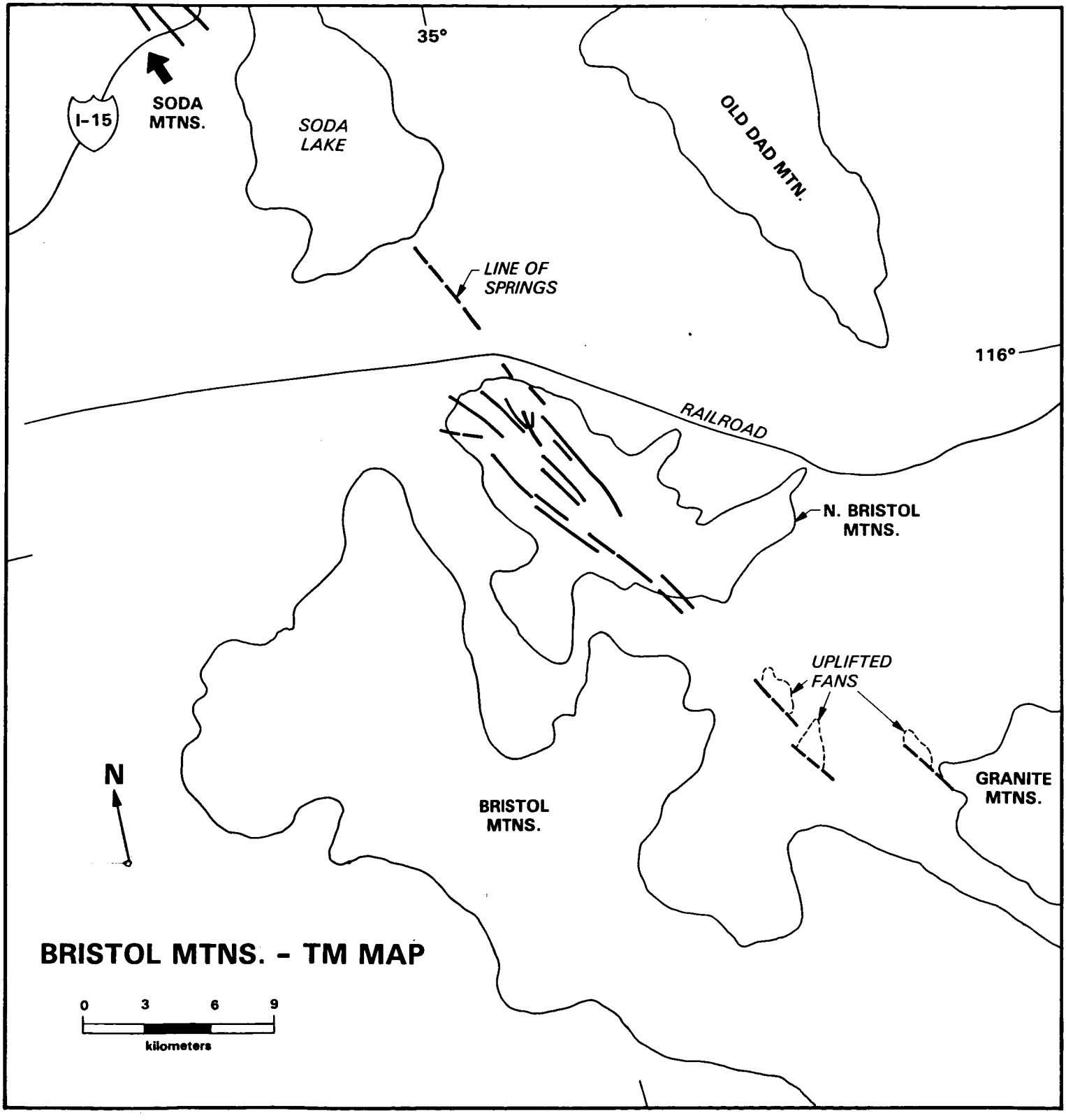
5
kilometers
N
RELATIVE FAN AGES
6 5 . . 2 1
OLD → YOUNG
SODA MTN. FAULT ZONE
BAKER
RED
PASS
LAKE
15

GRAVITY INTERPRETATION: VALLEY BETWEEN AVAWATZ AND SODA MTNS.



INTERPRETIVE SECTION THROUGH UPLIFTED FANS NORTH OF SODA MTNS.




35°
I-15
SODA MTNS.
SODA LAKE
OLD DAD MTN.
LINE OF SPRINGS
116°
RAILROAD
N. BRISTOL MTNS.
UPLIFTED FANS
GRANITE MTNS.
N
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BRISTOL MTNS. - TM MAP
0 3 6 9
kilometers